AIRS SRFs and Channel Properties

and

AIRS-RTA/AIRS-Ref-RTA

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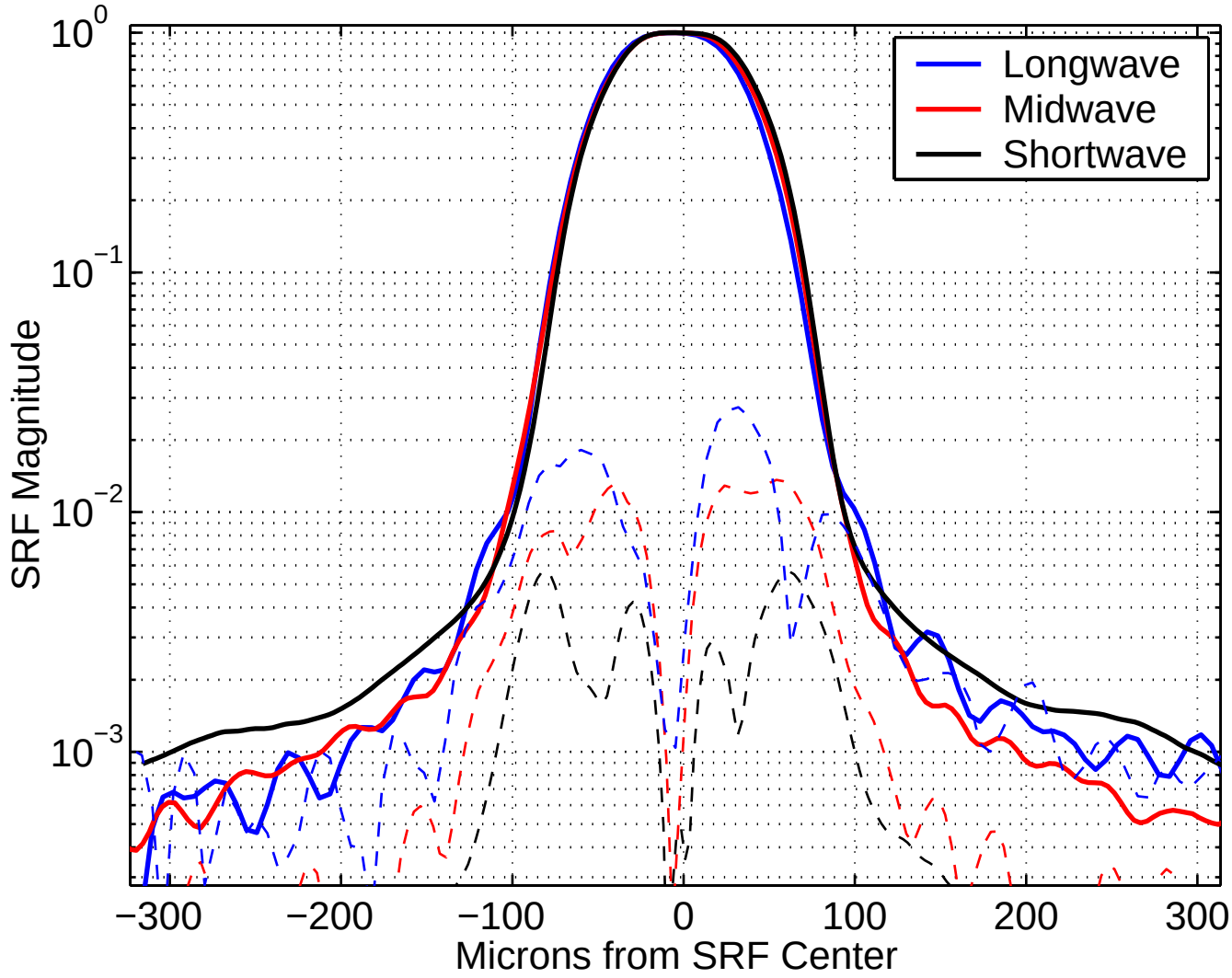
Overview of SRFs and Channel Properties

- Spectral calibration results very good, uncertainties below specification.
- Ground spectral calibration not sufficient for generating an AIRS forward model. Details must wait until after launch.
- The AIRS Project will supply spectral response functions (SRFs) to outside users. First pre-launch set already available.
- Will outline schedule for SRF updates.
- Note, no discussion of radiometric calibration here since not an issue for Level 1b users. However, radiometric calibration results are also very good.

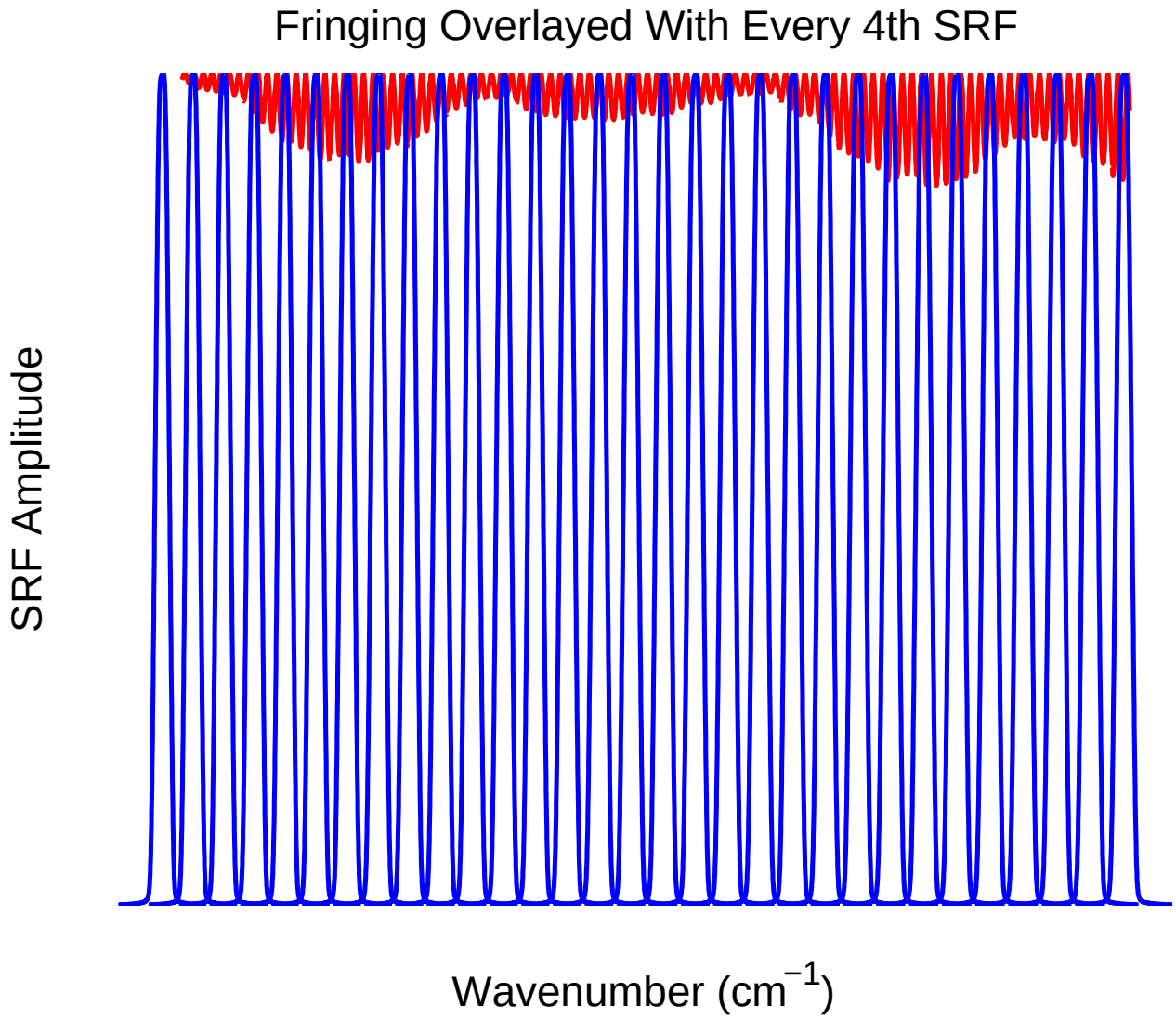
SRF Shapes


Longwave
Midwave
Shortwave
SRF Magnitude
10^{0}
10^{-1}
10^{-2}
10^{-3}
−300
−200
−100
0
100
200
300
Microns from SRF Center

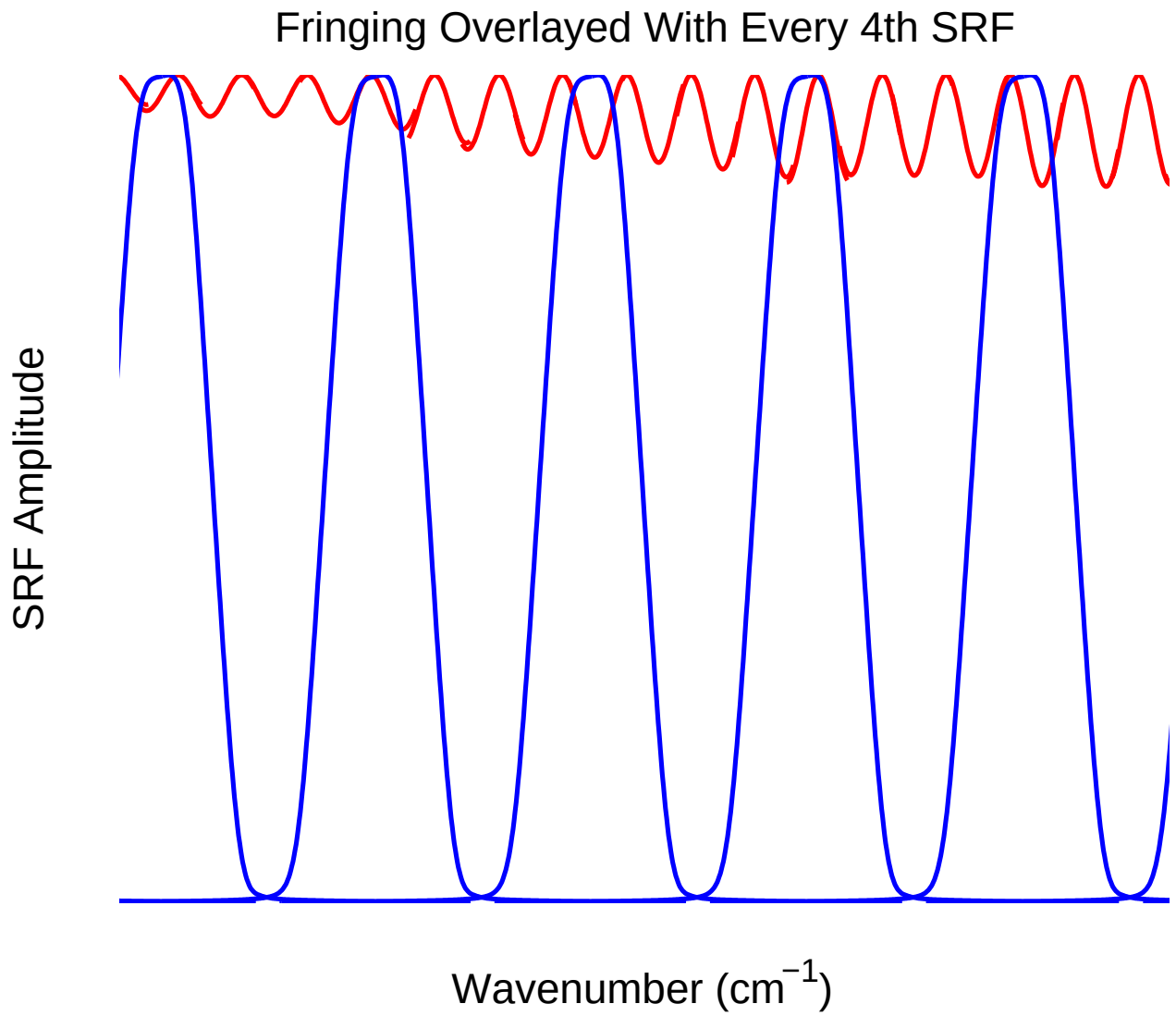
SRF Specifications

- Complete SRF shape with on an absolute wavenumber scale is all end-users need. The AIRS Project will supply this via look-up tables.
- The AIRS SRFs have the following components:
  1. Centroids (smoothed via the AIRS grating model). Known via ground calibration except for a single offset parameter in the grating model.
  2. Widths (smoothed empirically). Temperature independent.
  3. Shapes (scaled by width). Normalized shape determined on a per array basis (AIRS has 17 detector arrays.) *Almost* temperature independent.
  4. SRF shapes contain components due to interference fringing in the AIRS entrance aperture filters, which have been successfully modeled. The SRF centroids and the fringe phase vary with temperature at different rates. In-orbit conditions must be known to determine definitive positions of fringes and centroids. *Effect is quite small*.
- The pre-launch AIRS SRFs do not contain the fringing component, since it's phase cannot be estimated until the in-orbit conditions are known.

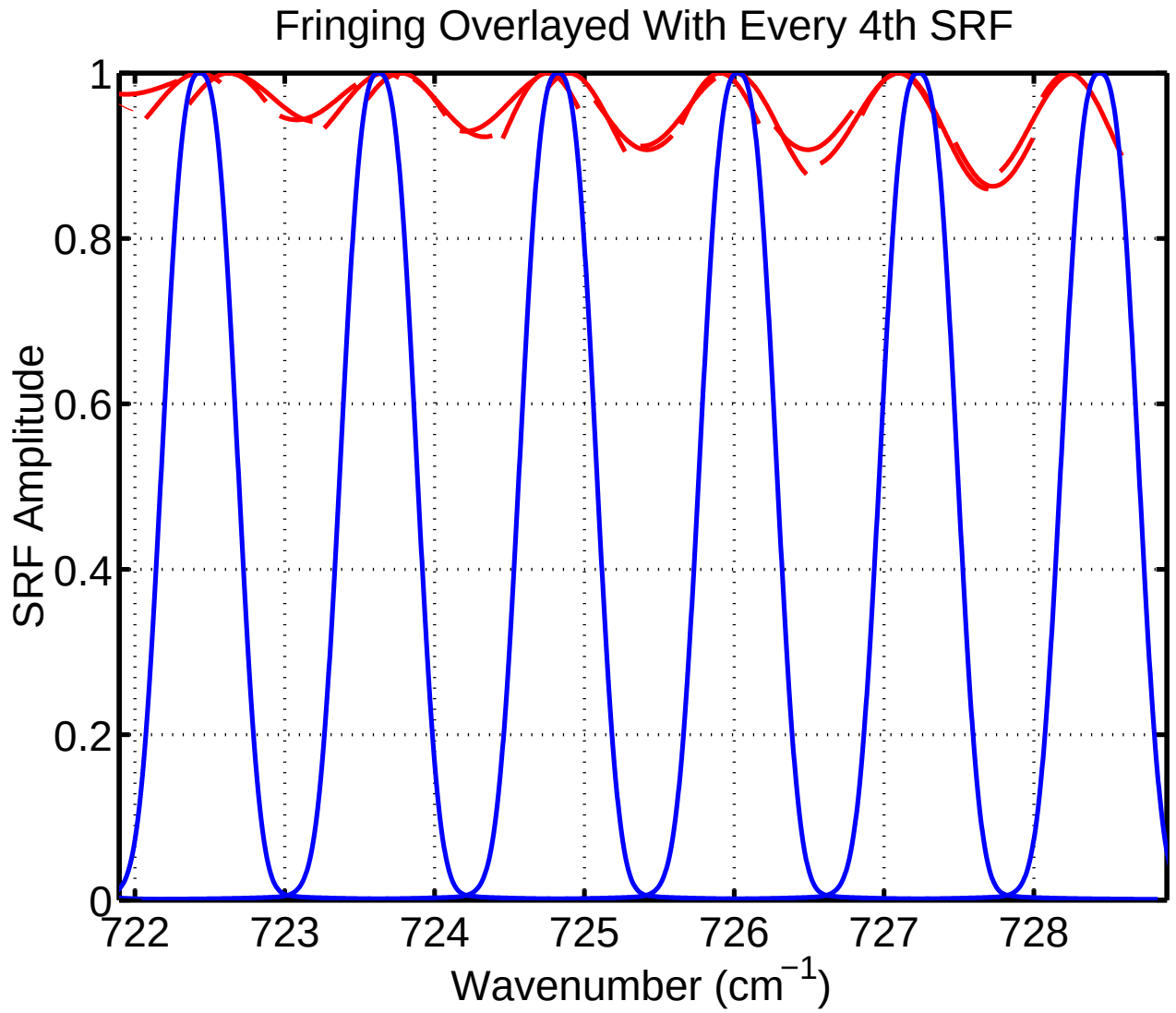
Fringes in the 2400 cm^{-1} Region



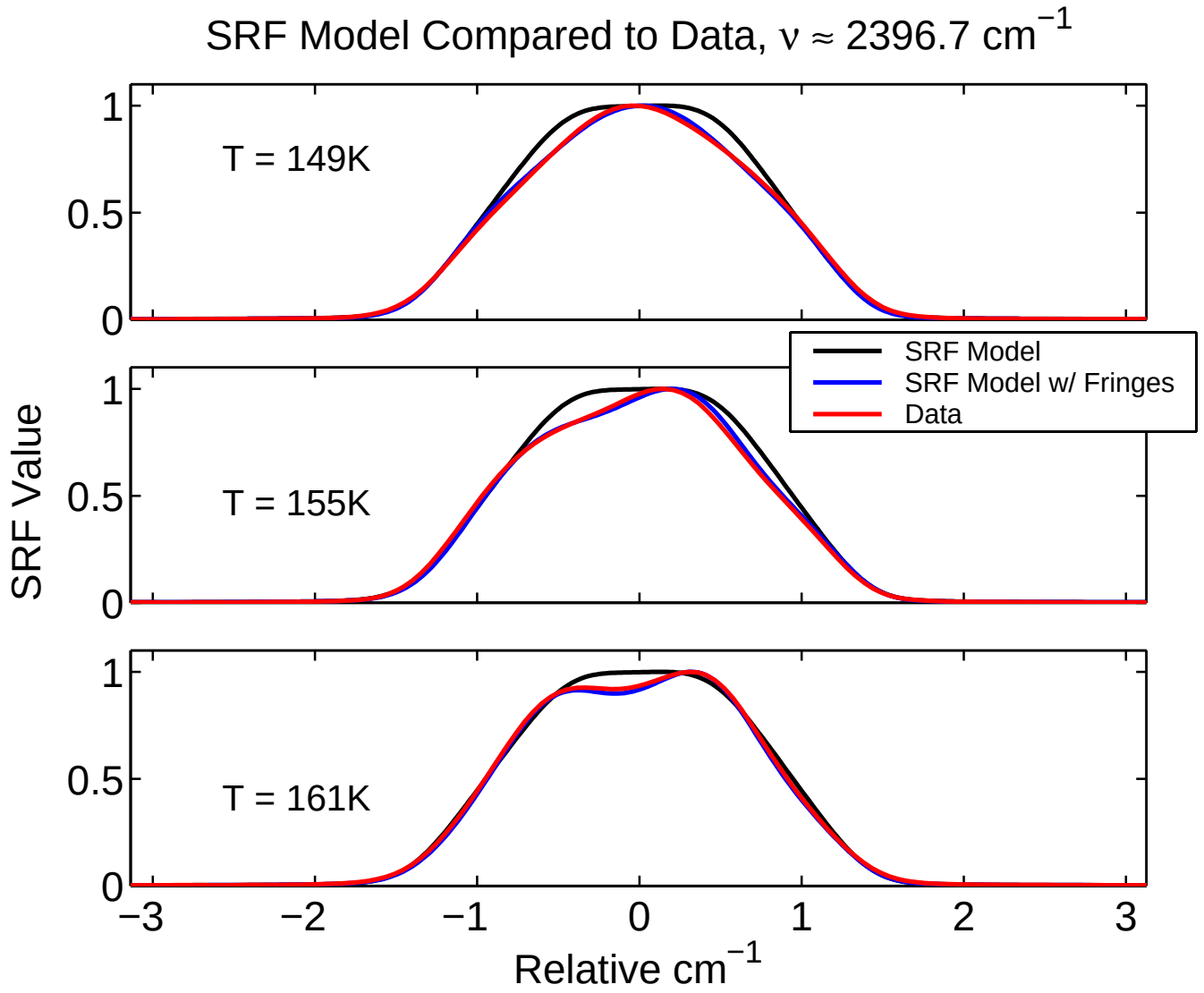
Fringes in the 2400 cm^{-1} Region



Fringes in the 725 cm^{-1} Region



Fringes Move Relative to SRFs with Temperature

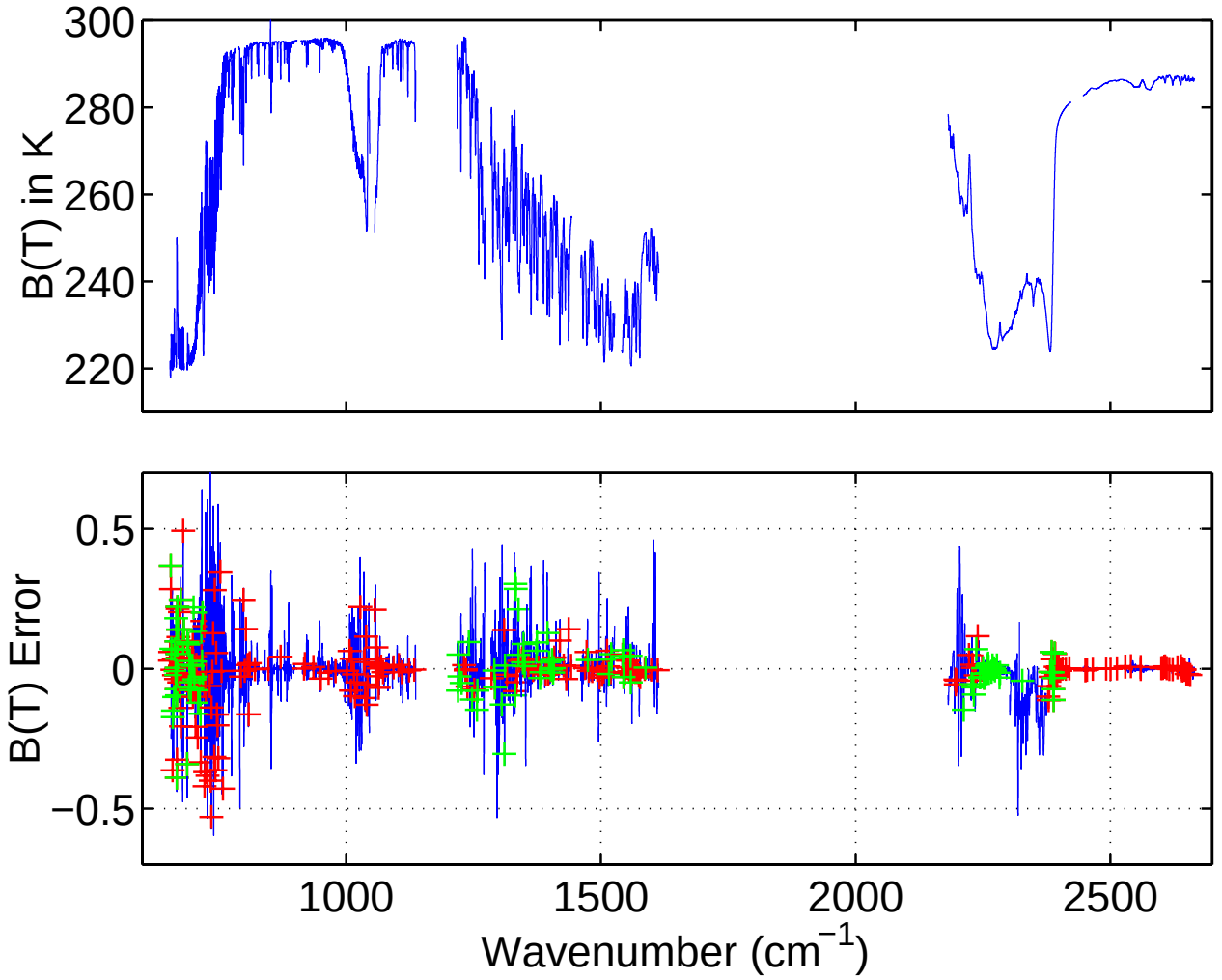


Final Determination of SRFs In-Orbit

- SRFs may/will change from their ground calibration values due to:
  1. Vibration during launch
  2. An unknown final operating temperature for the grating spectrometer and entrance filters.
- Present working assumption is that the AIRS operating temperature will be stable enough that variations in the SRF centroids (the most temperature sensitive parameter) can be neglected. Algorithms are being developed to re-sample the AIRS radiances to a fixed wavenumber scale *If long-term temperature variations occur.* This is considered to be unlikely.
- The single offset parameter needed by the in-orbit grating model will be derived from the up-welling radiances, and will be tracked on a per-granule? basis.
- The absolute fringe phase is only dependent on the temperature of the entrance filter, which is measured in orbit. We will attempt to validate the fringe phase by varying the AIRS operating temperature.

Over?-Estimated *Bias* Errors if Fringing Unknown

Standard Deviations are about 10X Smaller



Availability of SRFs to Outside Users

- Pre-launch SRFs (V 1.0) are available now at http://asl.umbc.edu/pub/airs/srf/srfhdf.html. Again, these do not include fringing, and assume a nominal instrument temperature of 155K.
- SRFs are stored in an HDF SD file as look-up tables, which include
  1. The SRF shapes on a non-uniform 471 point grid
  2. The widths, which determine both the width and wavenumber scale
  3. The absolute frequency of the "center" point of the SRF
- Users should also obtain the Channel Properties File from the AIRS Project, which contains a variety of flags denoting the quality of a channel radiance, SRF, and forward model parameterization.

Delivery Schedule for SRFs and AIRS-RTA

Date	Version	Comments
August 2000	FM V 5.0a	At launch frequencies, no fringes
November 2000	SRFs V1.0	At launch frequencies, no fringes
January 2001	FM V 5.0 b,c	2 more V 5.0 models for 3x finer grid
Launch + 3m	SRFs V2.0	Correct frequencies, fringes?
Launch + 4m	FM V 6.0	Correct frequencies, fringes?
Launch + 7m	SRFs V3.0	If required.
Launch + 8m	FM V 7.0	"Final" frequencies, fringes, improved parameterization and spectroscopy
Launch + 8m + 1yr	FM V 8.0	Con't improvements from V 7.0, plus any req'd variable gases

- Generally SRFs will be available 1 month before a new fast model is delivered to JPL
- The convolved layer-to-space transmittances (on the 100 AIRS layers) will be available, for our gas breakdowns, near the time period when a new FM is delivered to JPL.
- Delivery times assume special validation period starts by Launch + 2 months, which is unlikely.

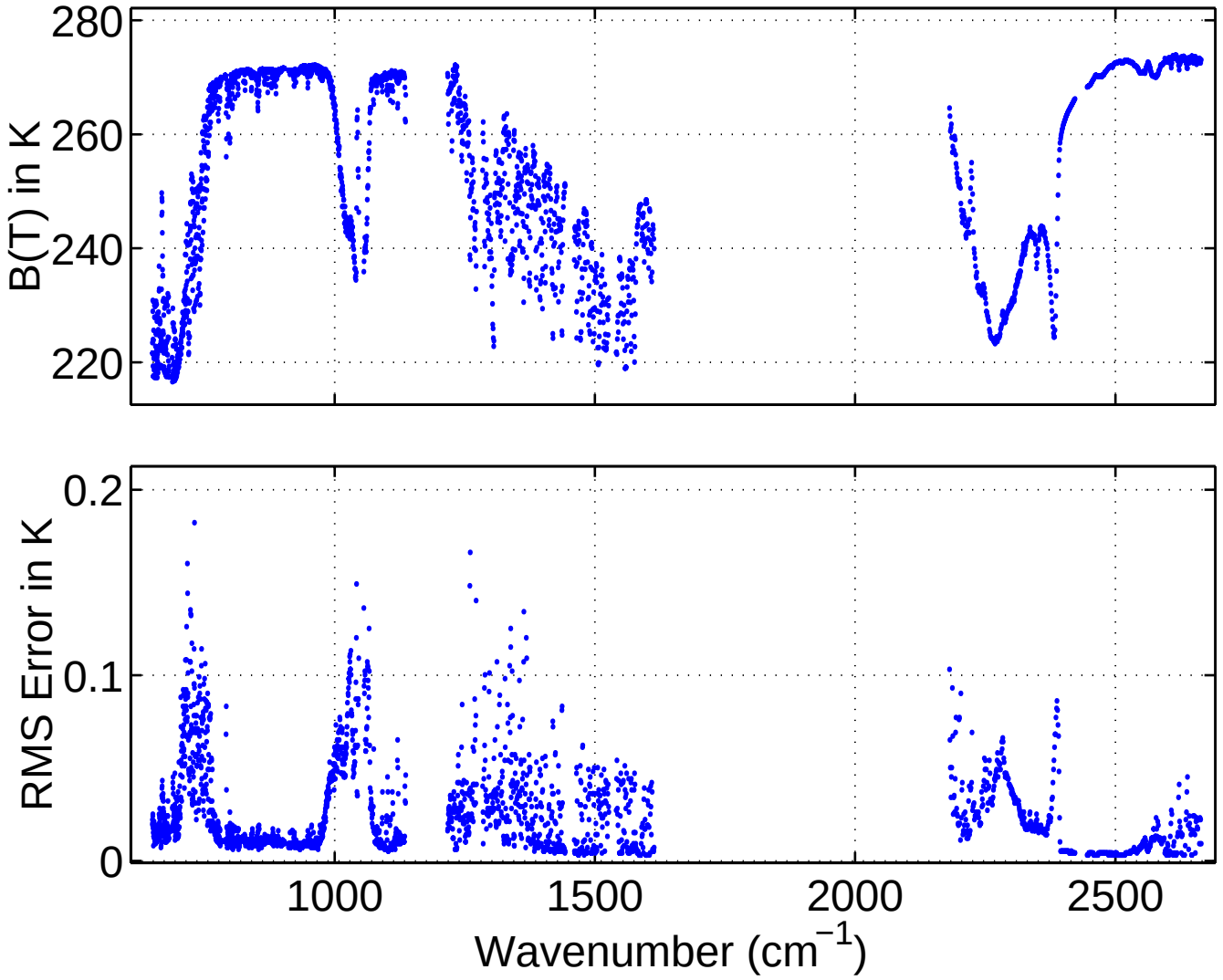
Overview of AIRS RTAs and their Validation

- UMBC supplies the fast transmittance parameterization to JPL for integration into the Level 2 retrieval software.
- UMBC can also supply three "stand-alone" *radiative transfer* codes:
  1. The "stand-alone" AIRS-RTA. This is a fast radiative transfer algorithm that uses the Level 2 fast transmittance parameterization. It should be identical to the radiative transfer calculations within the AIRS Level 2 software.
  2. The AIRS Reference Radiative Transfer Algorithm (AIRS-Ref-RTA) which is a pseudo line-by-line code that generates monochromatic radiances that are subsequently convolved with the AIRS SRFs. Based on kCARTA.
  3. Our working version of kCARTA, which is much more general purpose than the AIRS-Ref-RTA and more difficult to use.
- UMBC will concentrate on validation of:
  1. transmittance parameterization (and regression profiles), and
  2. spectroscopy validation.

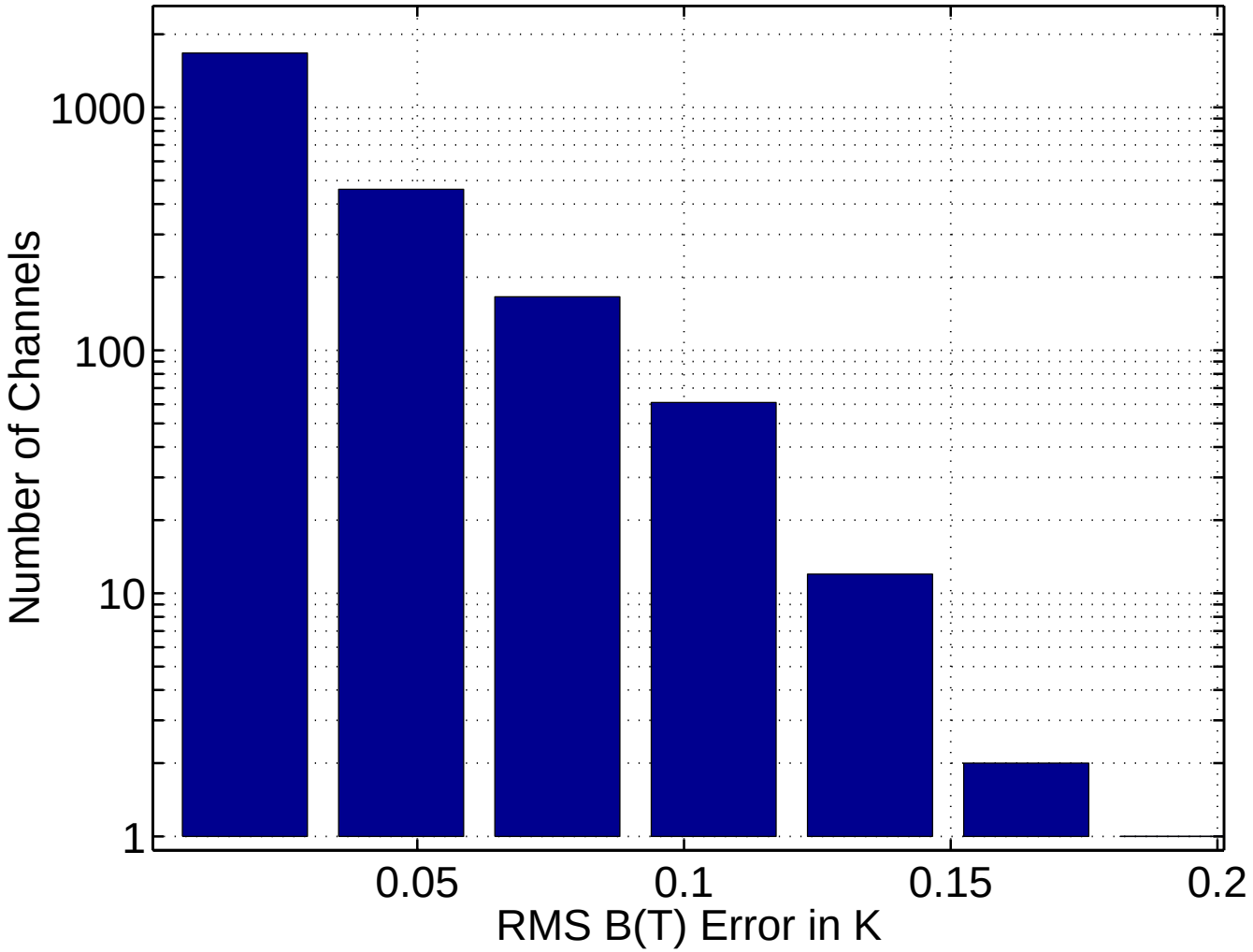
AIRS Fast Transmittance Algorithm

- Spectroscopy is based on UMBC's kCARTA pseudo line-by-line algorithm. kCARTA treats CO_2 line-mixing differently than other LBLs. *Differences are significant*.
- Algorithm is combination of PFAAST and OPTRAN (for some water channels). No tangent linear model or adjoint. AIRS algorithm uses finite-difference Jacobians for final retrieval.
- Fitting errors are quite low (see graphs)
- Previous analysis of transmittance model errors with an independent profile set show little degradation over fitting errors. Will be revisited soon with an independent profile set.
- Updates to RTAs will be based on improved SRFs/centroids, spectroscopy, parameterizations, and better estimates of (fixed) minor gas mixing ratios.
- Variable gases are H_2O, O_3, CO, CH_4, and CO_2. CO_2 mixing ratio can only be changed via a scale factor for the whole profile. (Not used presently.)

RMS *Fitting Errors* for AIRS-RTA (Fast Model)



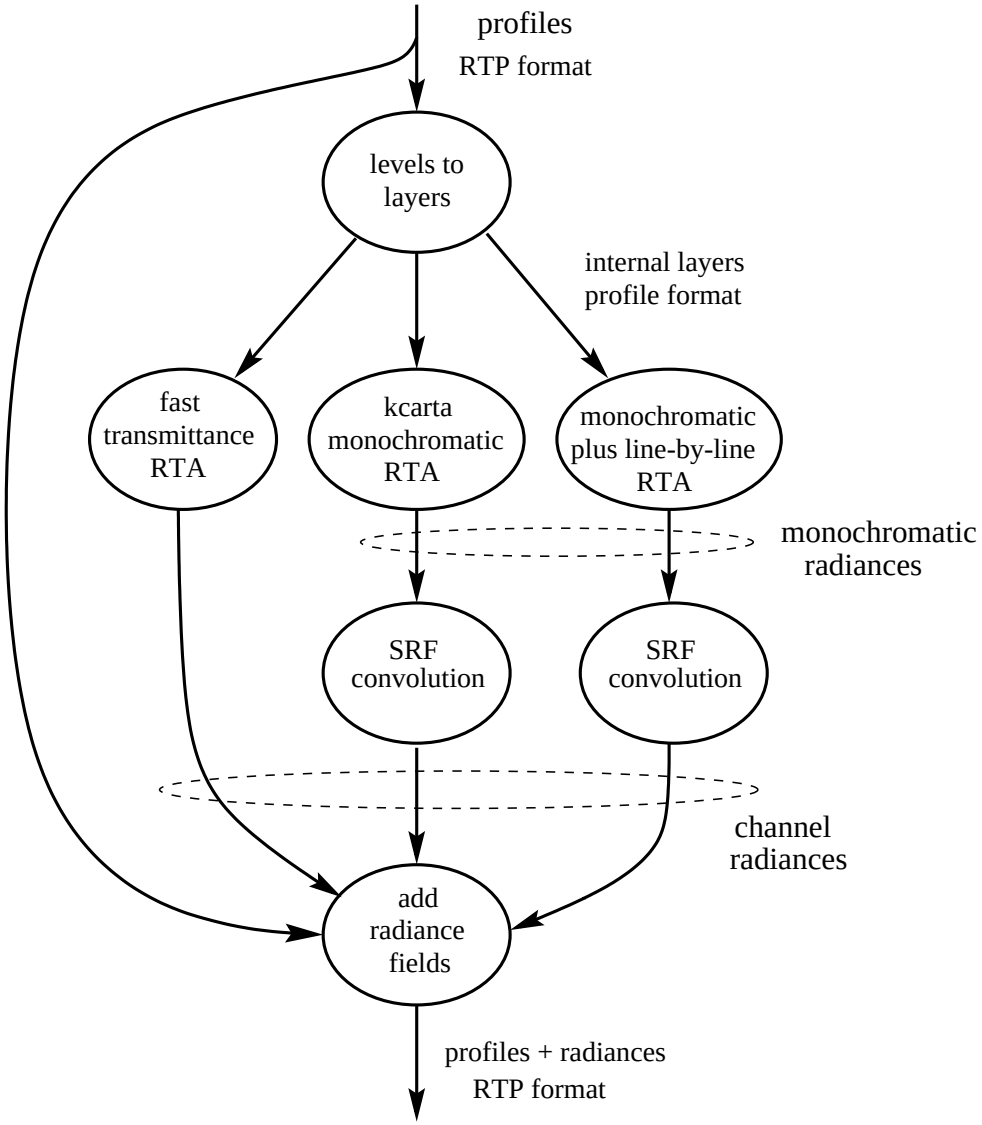
Histogram of RMS *Fitting Errors* for AIRS-RTA (Fast Model)



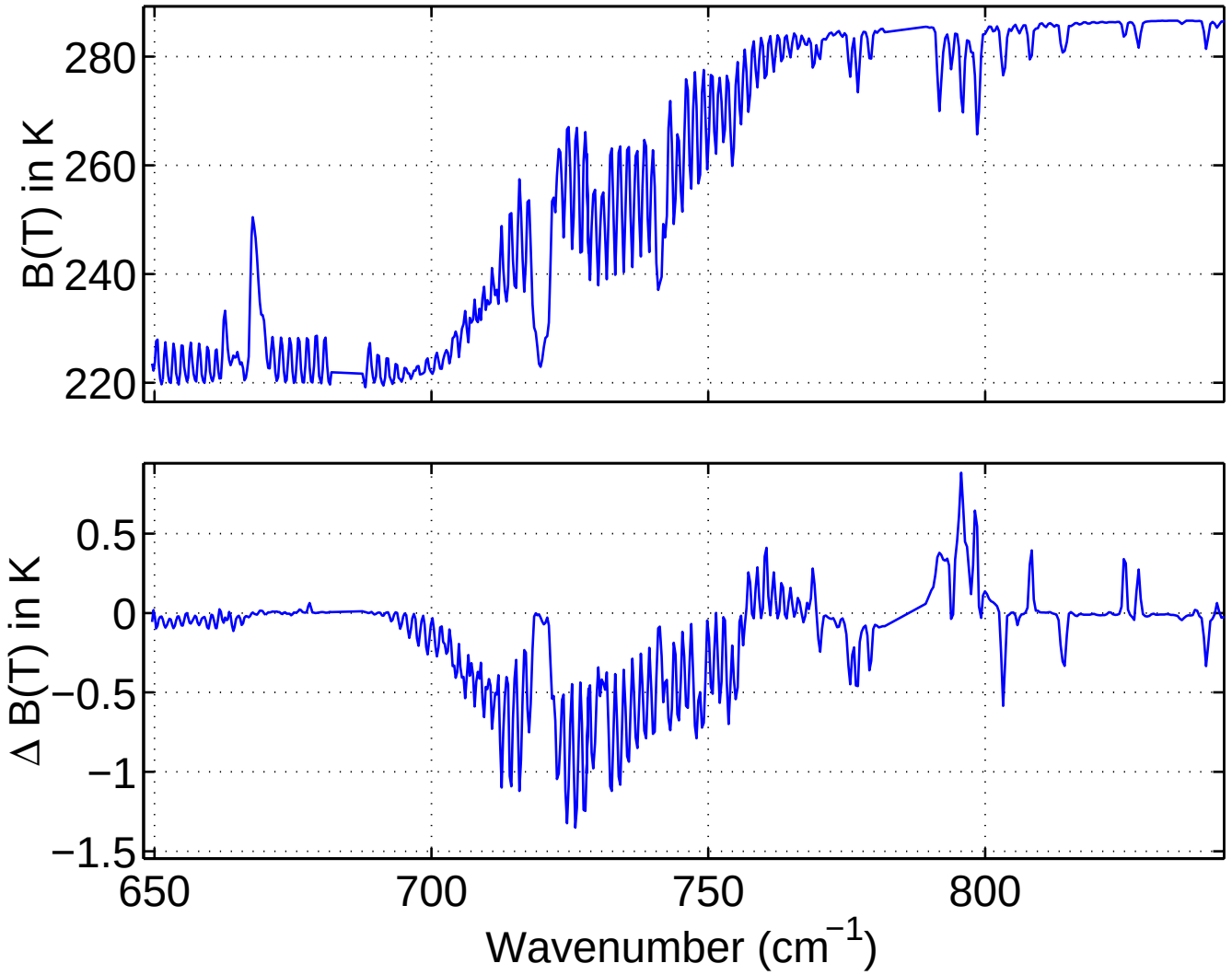
AIRS-Ref-RTA

- AIRS-Ref-RTA has line-by-line algorithm accuracies, based on kCARTA.
- Has new spectroscopy (P/R branch mixing in CO_2) that is not in other LBLs.
- Generates layer-to-space transmittances needed for developing AIRS-RTA (fast forward model). Only using standard kCARTA.
- Intended to be the reference for comparison to AIRS fast models.
- Only way to compute observed AIRS radiances before instrument stabilizes.
- Much more general purpose than AIRS-RTA
  - Channel centers can be selected. Will include most recent SRF definitions.
  - Allows all gas mixing ratios to vary.
  - Arbitrary layering possible.
  - Accurate reflected thermal/solar radiation
  - Hidden capability to include cirrus scattering via code from Frank Evans (U. Colorado) or via DISORT (real slow). Only using standard kCARTA
- Slow compared to AIRS-RTA. kCARTA takes roughly 30-60 minutes to compute all AIRS channels (not including convolution time), basically 0.5 -1 min per 25 cm^{-1}.

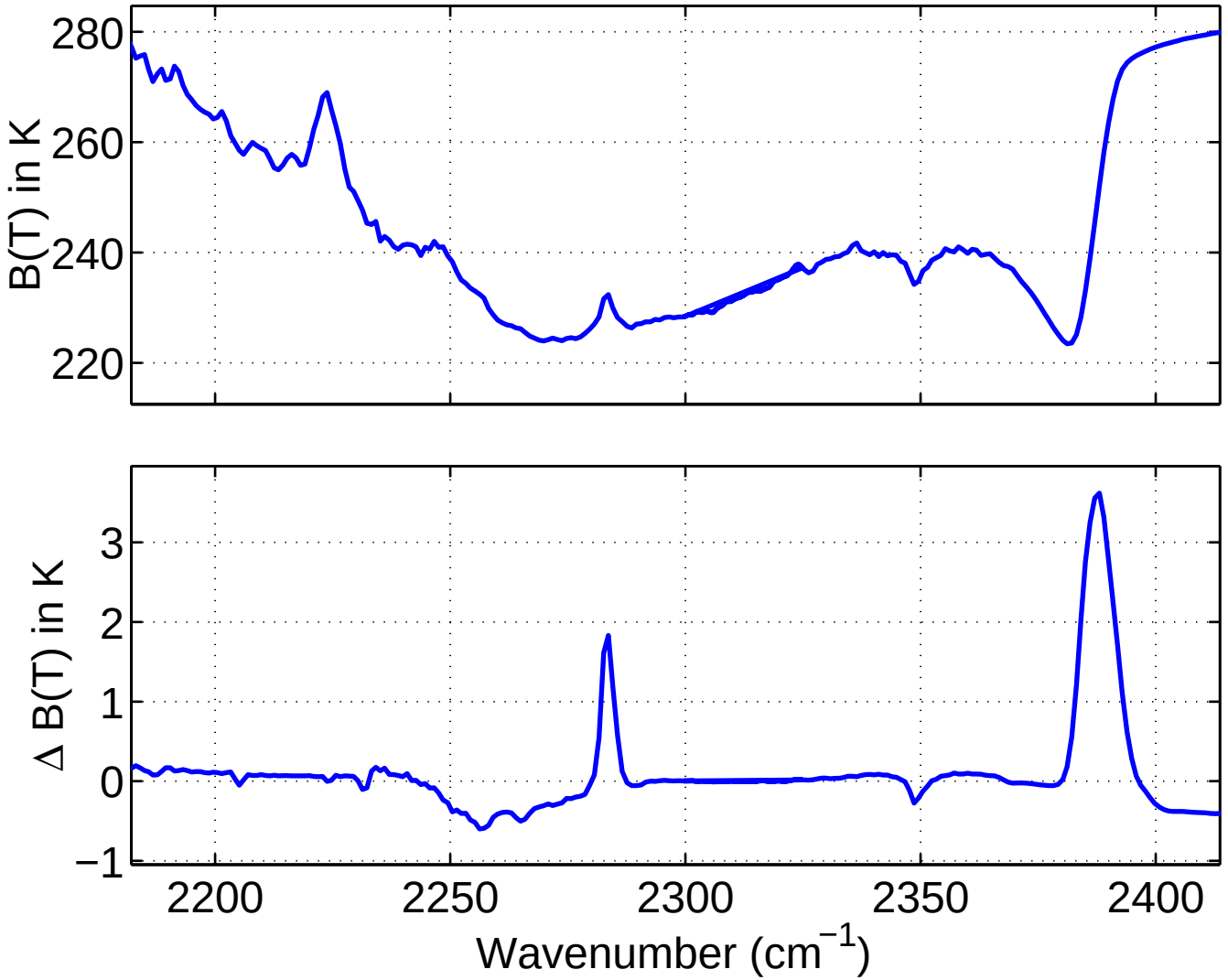
AIRS-*-RTA Structure



Differences Between kCARTA and Other LBLs



Differences Between kCARTA and Other LBLs



Validation of AIRS*RTAs, Esp. Spectroscopy

- We need bias and variance measurements on *most* channels, for a variety of atmospheric conditions.
- Examination of the radiance residuals for the almost continuous spectra produced by AIRS will be essential for differentiating between instrument, parameterization, and spectroscopy errors.
- UMBC will concentrate on special validation sites with projected high accuracy.
- NWP model data will help us examine forward model bias/variance over a wide range of atmospheric conditions. Will be especially useful for validation by examining computed versus observed correlations between channels.
- As UMBC develops new AIRS-RTAs we will need to re-do bias/variance calculations. Thus, we hope to download appropriate model data for a 1-2 month time period. Eventually use Level 2 cloud-cleared radiances for validation?
- Possible scenario; we download NWP model data from NESDIS system for a 1-2 month period. During that time we also download AIRS radiance data *(all channels)* deemed “clear” by an algorithm running on the NESDIS system for radiance residual processing on NWP model profiles.

Forward Models Used for AIRS Research

Our interest: validation and improvement of AIRS-RTA

Organization	Spectroscopy	Parameterization
AIRS Project	kCARTA	AIRS-RTA
*DAO	kCARTA (via NCEP?)	"Optran (via NCEP?)"
NCEP	kCARTA?	"Optran"
ECMWF	GENLN2	RT-TOVS/IASI-A?
UKMO	kCARTA?	RT-TOVS/IASI-B?

* Only for radiance assimilation? AIRS-RTA for retrieval assimilation.

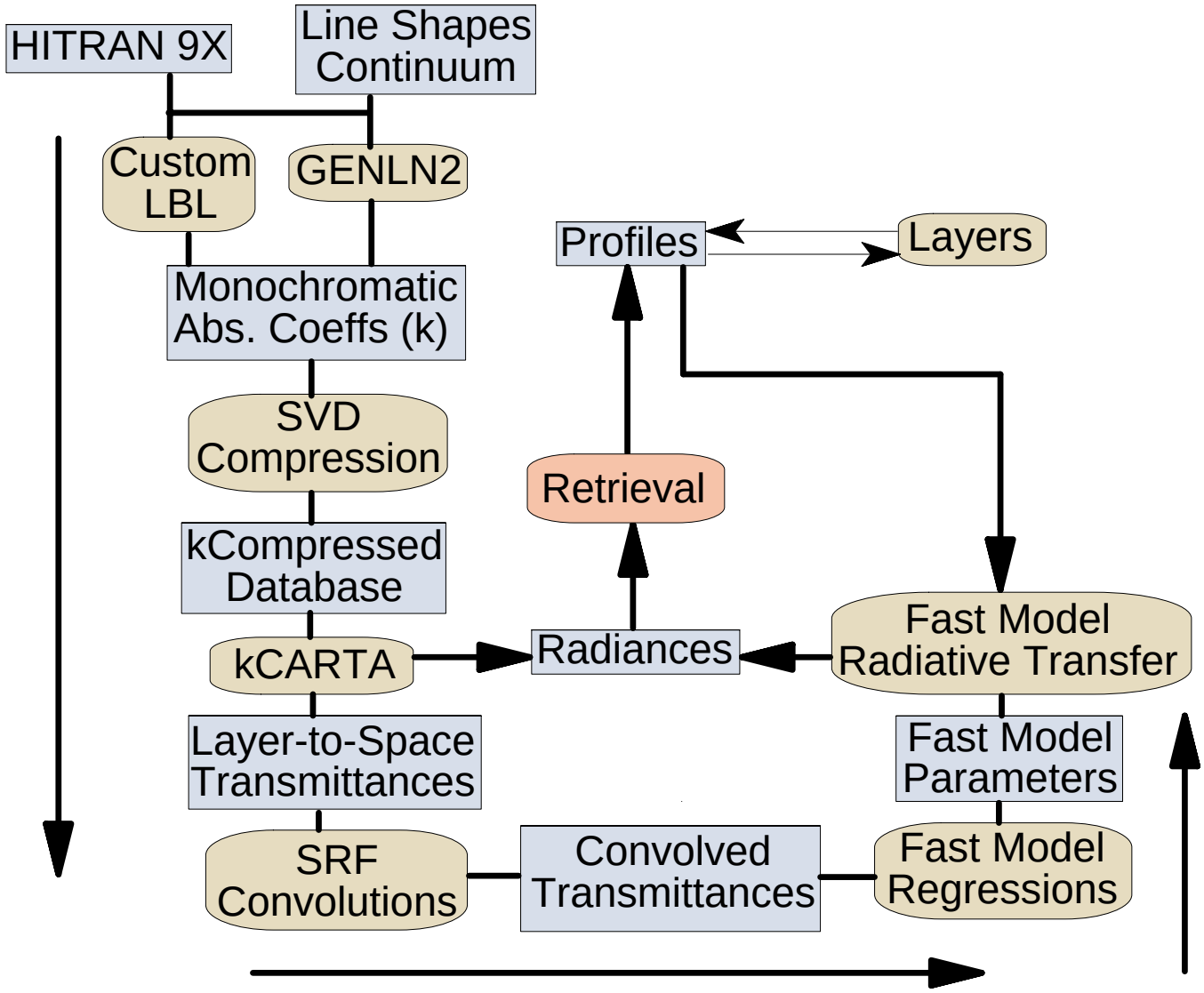
Validation Issues

- "Clear" flags and processing very important for RTA validation.
- Need radiance residuals/statistics for all channels to validate system.
- Initially use ocean observations/model data for validation.
- Eventually need to use land surface observations, how will we bootstrap emissivities used in RTA evaluation?

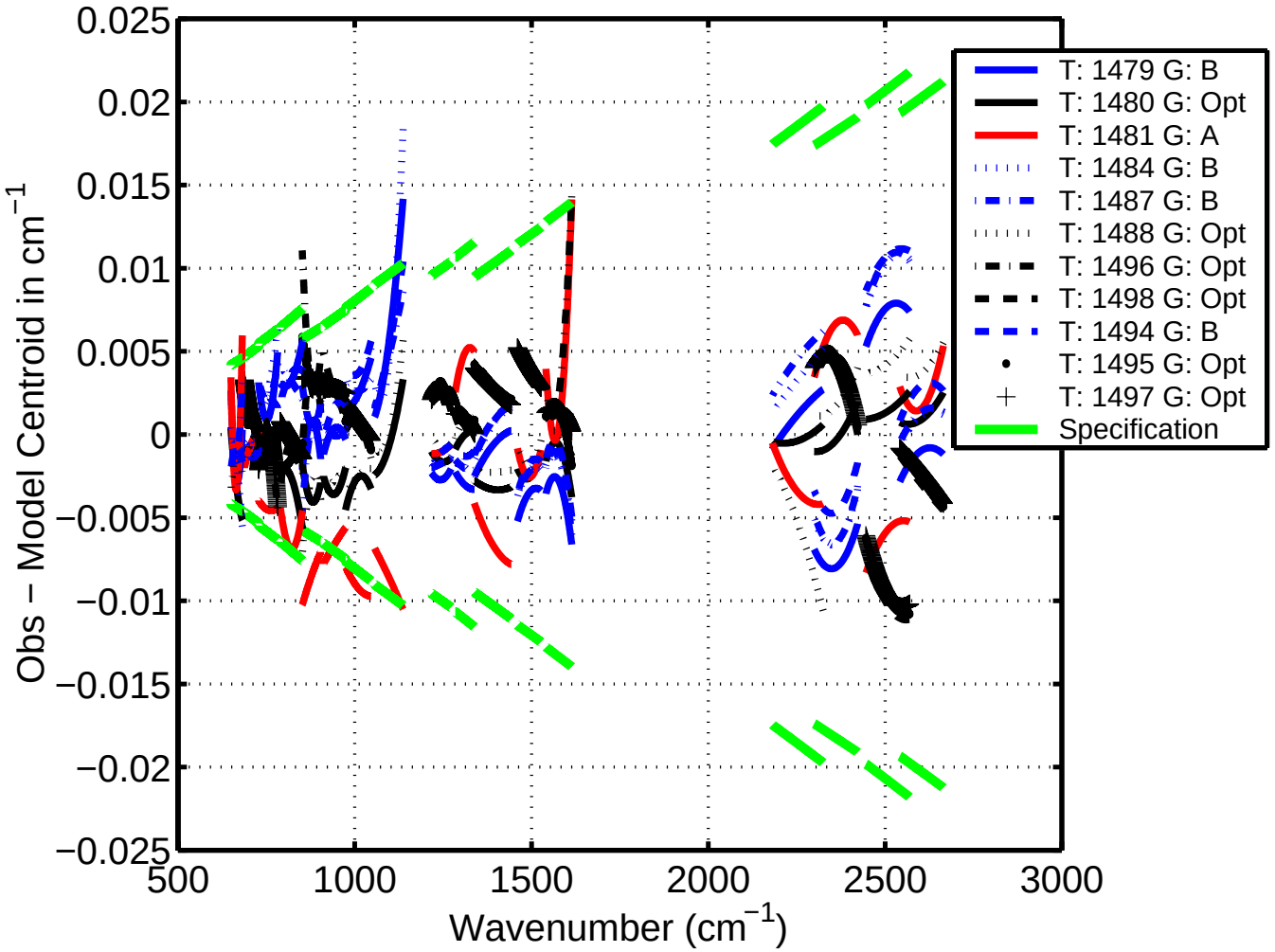
Supplementary Material Follows

The following slides document the development of the forward model and accuracy of the spectral calibration.

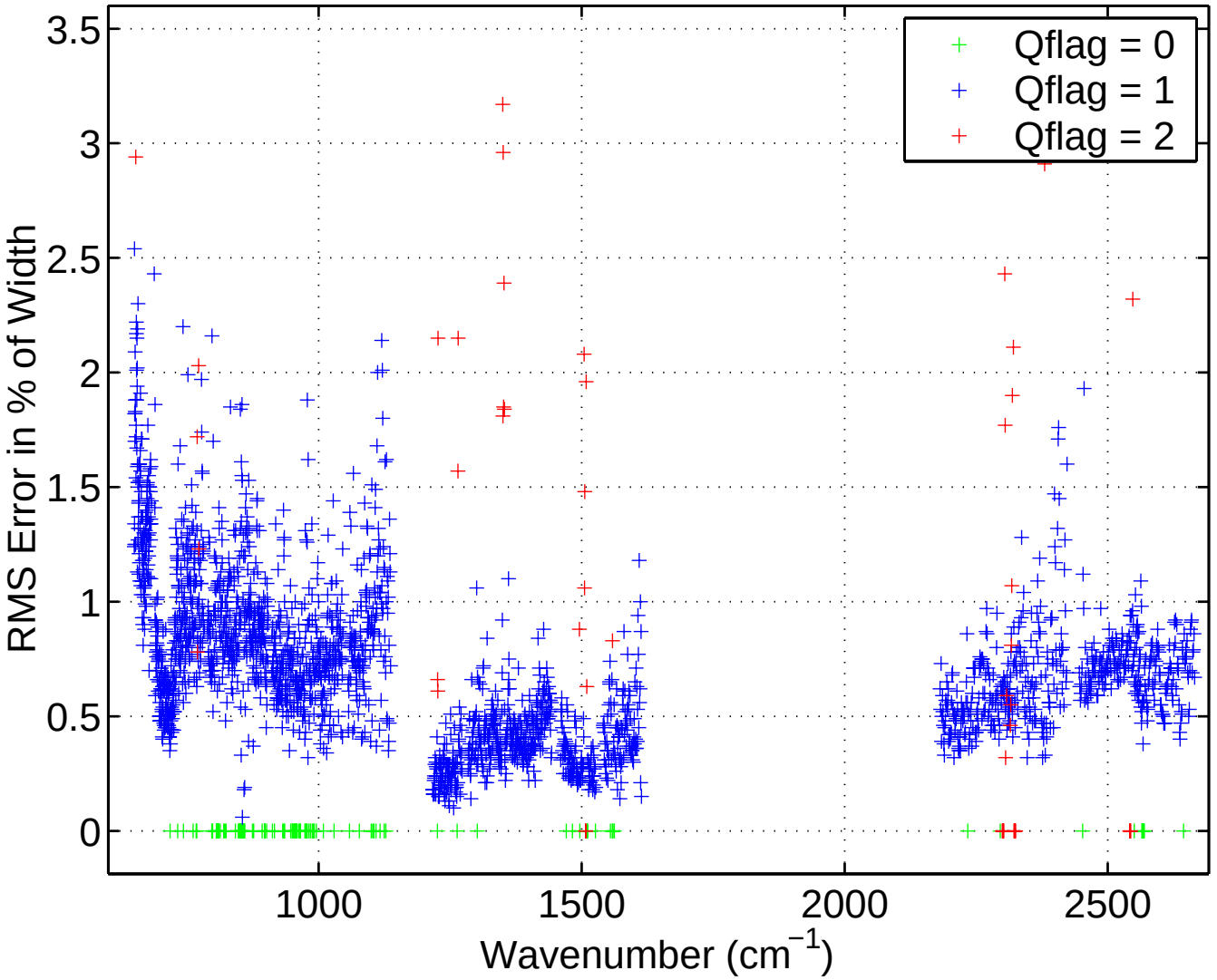
Conceptual Flow for AIRS-RTA Improvements



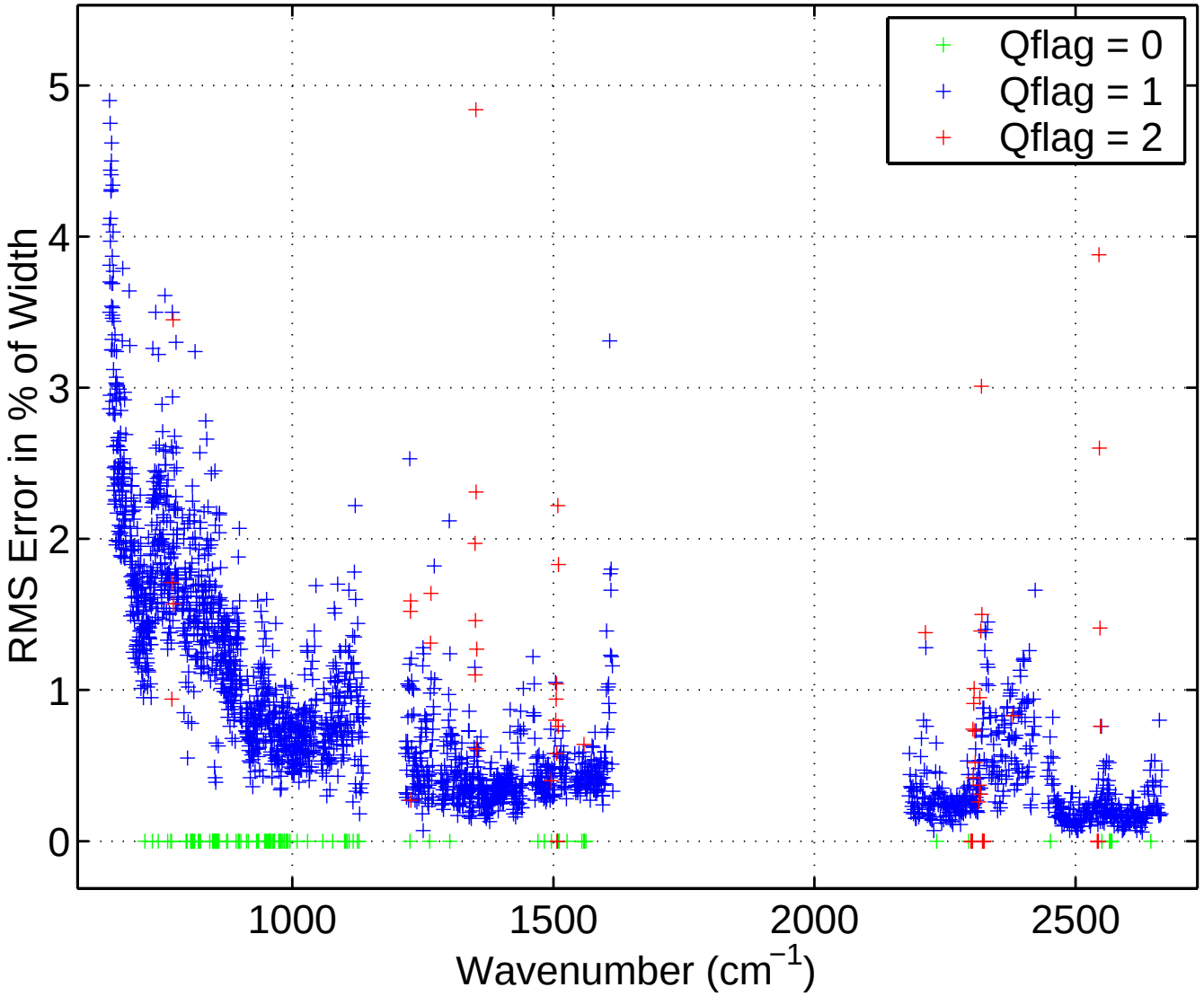
Grating Model Errors (centroids) - Below Specification



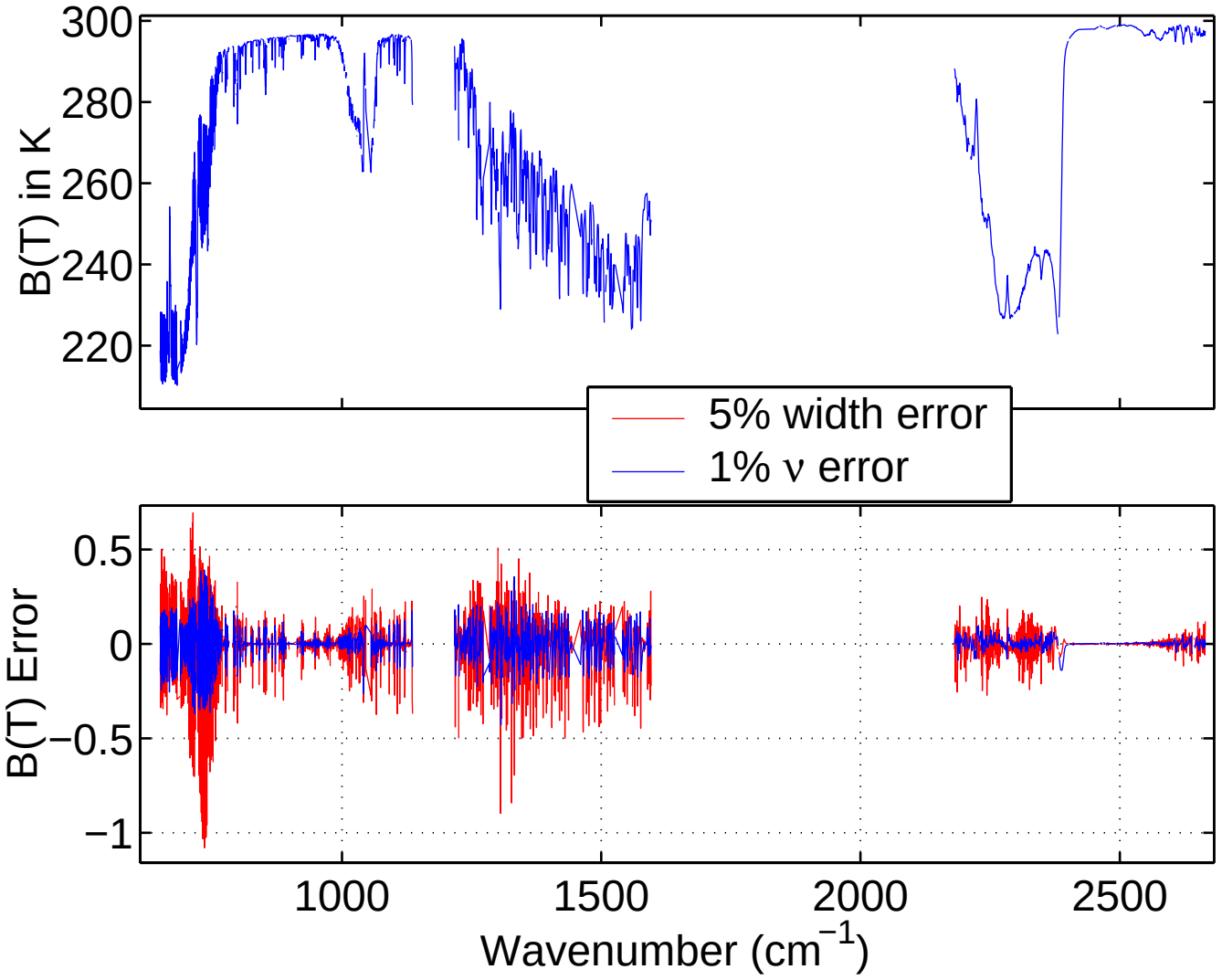
Grating Model RMS Errors



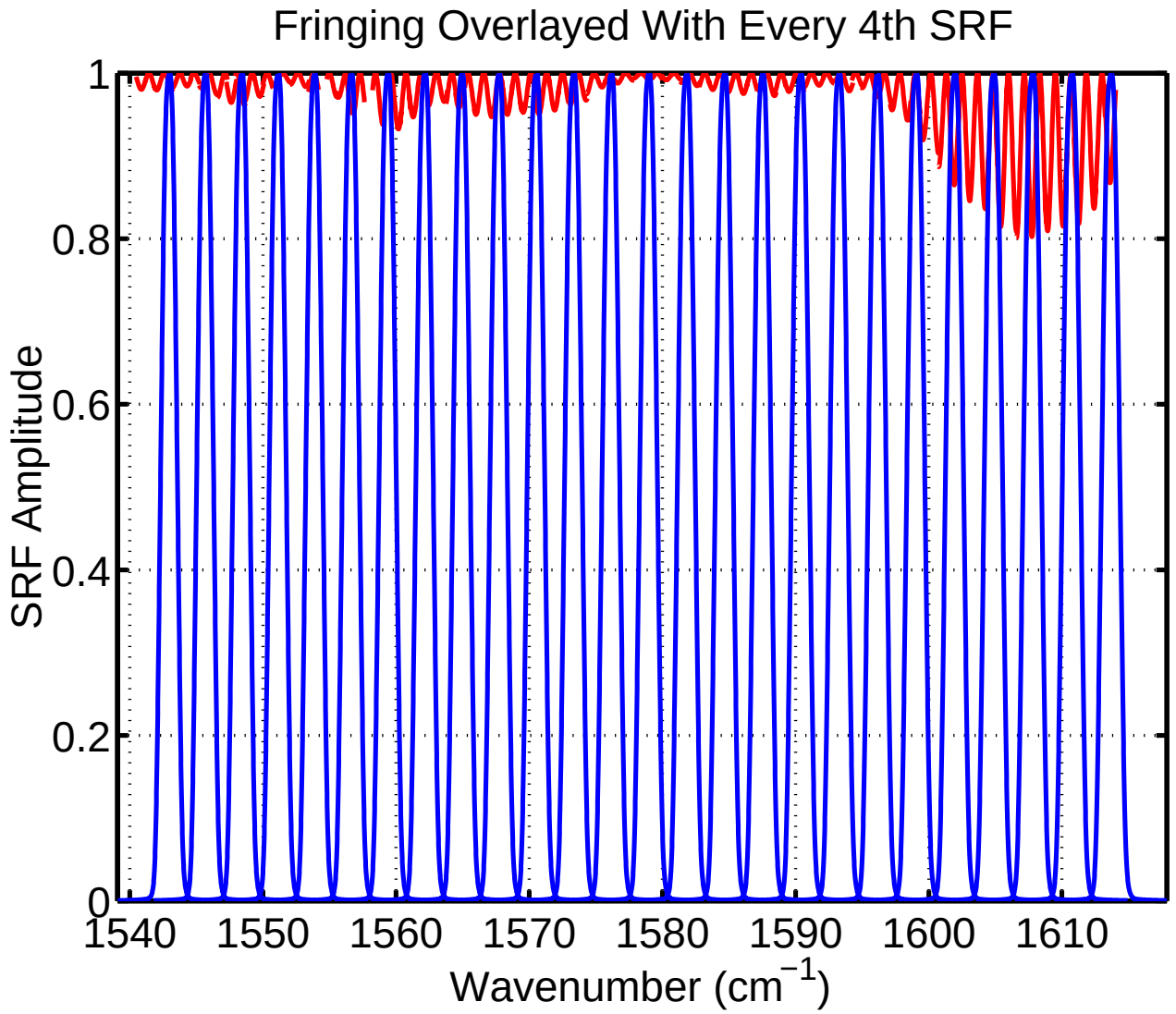
SRF Width Errors - Below Specification



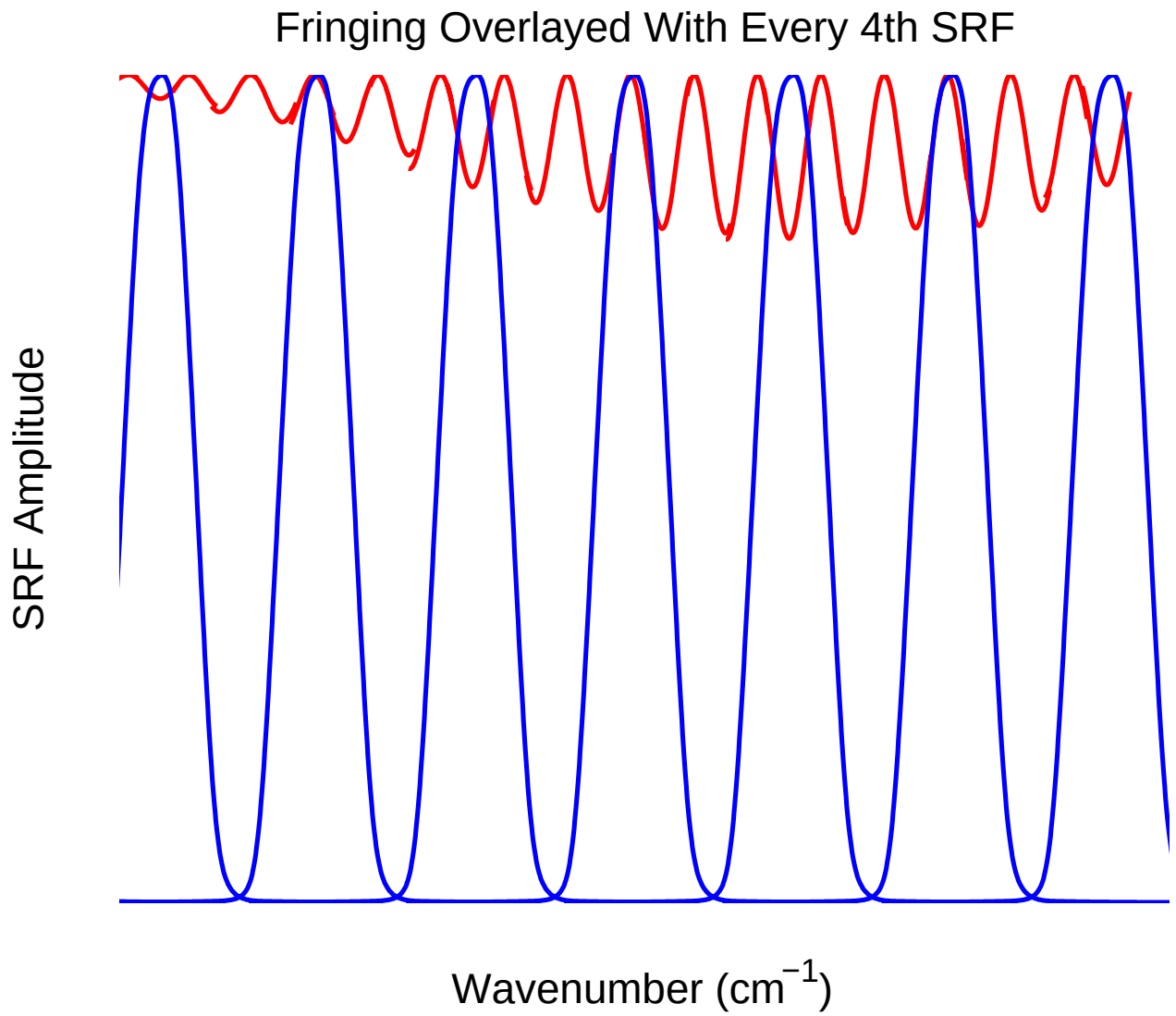
Sensitivity of B(T) to SRF Centroid, Width Errors



Fringes in the 1600 cm^{-1} Region



Fringes in the 1600 cm^{-1} Region



Model SRFs Compared to Calibration Data